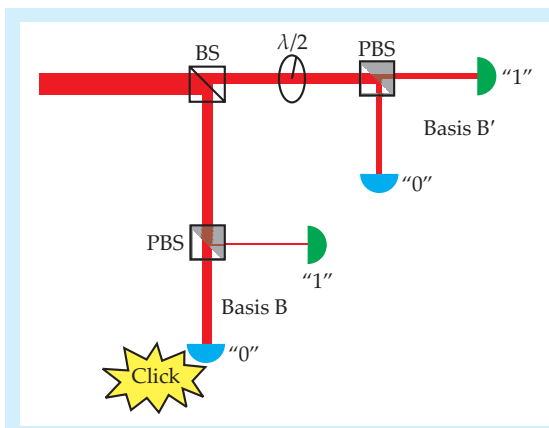




**Figure 2.** Passive basis choice using an ordinary beamsplitter (BS). A single photon would be detected in one basis or the other with equal probability. But a faked state can force a detection in the basis of choice.

ceiver chooses from the same set of bases.) Alice and Bob then confer about which bases they used, discard all events for which they used different bases (or in which one of them failed to make a measurement), and they are left with identical sequences of zeroes and ones that only the two of them know.

In principle, the process is unhackable: Because it's physically impossible to observe a quantum state and reliably regenerate the same state, any attempt to eavesdrop on the photon transmission should be instantly detectable. (See the Quick Study by Bill Wootters and Wojciech Zurek in *PHYSICS TODAY*, February

2009, page 76.) But if Eve the eavesdropper intercepts the photons and retransmits the corresponding faked states, Alice and Bob may not suspect that anything is amiss. In that way, Makarov, Kurtsiefer, and colleagues demonstrated that they can eavesdrop on quantum cryptography systems, including commercial devices.<sup>5</sup> Their procedure isn't foolproof; it exploits weaknesses of the devices, not of quantum cryptography itself. Like a loophole-free Bell test, a perfectly secure quantum cryptosystem remains an outstanding goal.

Johanna Miller

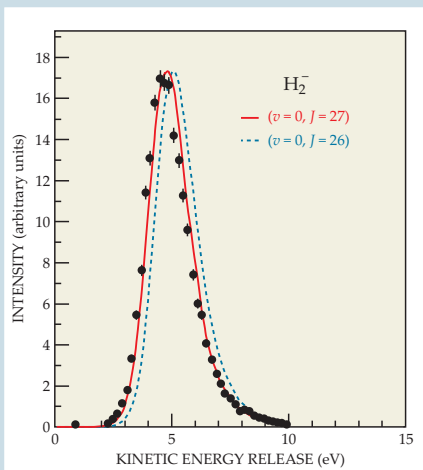
## References

1. A. Einstein, B. Podolsky, N. Rosen, *Phys. Rev.* **47**, 777 (1935).
2. J. S. Bell, *Physics* **1**, 195 (1964).
3. A. Aspect, *Nature* **398**, 189 (1999).
4. I. Gerhardt et al., *Phys. Rev. Lett.* **107**, 170404 (2011).
5. I. Gerhardt et al., *Nat. Commun.* **2**, 349 (2011); L. Lydersen et al., *Nat. Photonics* **4**, 686 (2010).

## physics updates

These items, with supplementary material, first appeared at <http://www.physicstoday.org>.

**Negative ions of molecular hydrogen.** The long-standing puzzle of how a hydrogen molecule can hold on to an extra electron for so long has finally been experimentally resolved. The negative molecular ion  $H_2^-$  is the simplest of all molecular anions. It's unstable, but the details of its unstable states have been the subject of much confusion. They matter beyond the confines of molecular theory because an  $H_2^-$  collision complex is thought to be relevant to the formation of the first generation of stars. A clear



signal of metastable  $H_2^-$  with a lifetime of microseconds was found in a 2005 mass-spectrometer experiment. Theory, however, predicted that no  $H_2^-$  state could survive longer than femtoseconds unless the separation between the protons was much bigger than the 0.7-Å spacing of the neutral  $H_2$  ground state. Now for the first time, the details of the metastable state have been revealed through so-called Coulomb-explosion imaging of its wavefunction by a group at the Max Planck Institute for Nuclear Physics in Heidelberg. The team accelerated an ion beam with a small  $H_2^-$  component to 1 MeV and then stripped off all the electrons by passing the  $H_2^-$  ions through an ultrathin carbon foil. The two suddenly freed protons repelled each other and were detected down-

stream. The observed distribution of proton-pair kinetic energies thus released was best fitted by an ionic wavefunction with a mean interproton spacing of about 3 Å and a rotational quantum number  $J$  of 27, as shown in the figure. The centrifugal barrier created by such high spin causes the large inter-nuclear separation that accounts for the metastable state's lifetime of almost 10 μs. (B. Jordon-Thaden et al., *Phys. Rev. Lett.* **107**, 193003, 2011.)

—BMS

### A handheld optical device for image-guided surgery.

Magnetic resonance imaging (MRI) and computer-aided x-ray tomography (CT) can both provide surgeons with an image of a malignant tumor before an operation. But neither technique is compatible with surgery. To excise a tumor without damaging healthy tissue, a surgeon needs a safe, convenient means to see the tumor's edges while the patient lies on the operating table. A collaboration led by Huabei Jiang of the University of Florida in Gainesville and Lily Yang of Emory University in Atlanta aims to reach that goal with an imaging system based on fluorescent molecular tomography (FMT). The patient—or at this stage of R&D, the lab mouse—is given a dose of nanoparticles, which make their way to a tumor, stick to its surface, and fluoresce in the near-IR. Photons in that waveband can penetrate about a centimeter into tissue, but they also scatter heavily, which complicates imaging. Forming a surgically useful 3D image entails using a sensitive and compact imager that can view the target from several angles and then applying a sophisticated reconstruction algorithm. The front end of the Gainesville–Emory imager consists of 25 optical fibers bundled together like a handful of pencils. Ten of the fibers deliver near-IR laser light to the target; the other 15 send the returning fluorescent light to a CCD detector. Moving the fibers over the target yields the image. In a recent test, the FMT imager reliably delineated tumors 5 mm beneath a mouse's skin with a precision of 0.5 mm laterally and 1.5 mm axially. (Q. Zhao et al., *Med. Phys.* **38**, 5873, 2011.)

—CD

### Aligning scattered light for pain-free diagnostics.

Though tried and proven, conventional portable diagnostic